General View of the Ebro Observatory.

# THE EBRO OBSERVATORY, TORTOSA, SPAIN.

By M. Selga, S. J.

The Ebro Observatory is located in the southern part of Cataluña, to the north of the old kingdom of Valencia, near the mouth of the Ebro River at a distance of about 20 kilometers from the sea. Situated on the edge of a small plateau which rises from the western part of the Ebro Valley some 40 meters above it, and at an altitude of 51 meters above the level of the sea, it commands a view which is a delight to the eye. To the east and south one sees in the immediate foreground the town of Roquetas, and beyond, the city of Tortosa with its architectural monuments, busy factories, olive-oil refineries, and old fortifications. The majestic Ebro River, just at the end of its course, winds thru beautiful orchards of oranges, pears, peaches and almonds. Twelve kilometers to the west are seen the arid and fantastic Caro and Espina mountains. The olive tree grows all over the small hills and endless plains. The climate is mild, rather dry, and the percentage of sunny days is high. The latitude of the observatory, determined by the Talcott method and by connection with geodetic points is $40° 49' 14''$ N.; the longitude is E. Greenwich $0^h 1^m 58^s$.

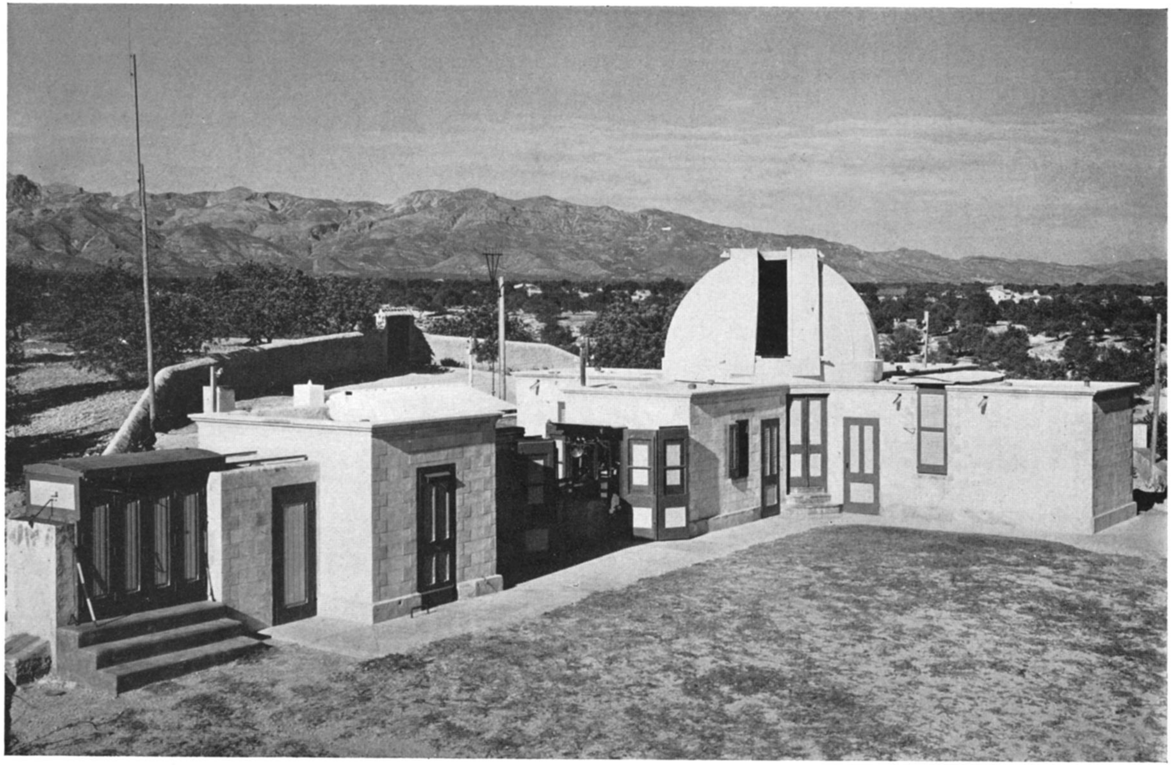
The founder and present director of the Ebro Observatory is Rev. Richard Cirera, S. J. While in charge of the magnetic department of the Manila Observatory, Manila, P. I., the advisability of obtaining simultaneous observations of solar activity and terrestrial magnetism was forcibly impressed upon his mind. His visit to the principal observatories of France, Belgium, England, Germany, Austria and Italy, and the scientific suggestions of prominent continental astronomers—Messrs. Deslandres, Evershed, Mascart, Loewy, Moureaux, Vicentini, Schwarzschild, Grablowitz and Landerer—culminated in the establishment of an astrophysical observatory at Tortosa, where the principal object is to find out the relation between solar activity and the atmospheric and magnetic variations of our planet. The observatory is of a private character and is not connected with any state college or university. The

Province of Aragon of the Society of Jesus is to be credited with the scientific triumph of having established in Tortosa a philosophical department, chemical laboratory, biological station and astrophysical observatory. Prominent business men and highly cultured citizens gave their support to the observatory: the Ebro spectroheliograph, the first of the kind to be used in Spain, is a munificent gift of Mr. GIRONA; but it is to Mr. PEDRO GIL DE MORA that the observatory looks as its greatest benefactor and quasi-founder.

The principal instruments of the observatory have been in regular use since 1905. The Tortosa observations of the solar eclipse, August 30, 1905, have proved of high value to solar research and the observatory was the observing station of several parties, from Spain and abroad, and the meeting place of prominent astronomers of France, England, United States, Germany, Belgium, Spain and Portugal. In August, 1910, the director attended the meeting of the International Union for Coöperation in Solar Research held at Mount Wilson, Pasadena, California, during the week of August 29th to September 4th. This occasion afforded him both the opportunity and the pleasure of visiting the leading observatories of the United States. The reflections on his scientific travels in Europe, as well as in America, were embodied in his book, "Viajes Científicos."

The coöperation of the observatory in every astronomical or magnetic investigation of general character has been sought by both parties of the Spanish government. Lately an appropriation was passed by both Houses to defray the expenses of the publications of the observatory. Thru the efforts of the director, an astronomical section was created in the Spanish Association for the Advancement of Science. King ALFONSO XIII himself paid a highly complimentary visit to the observatory. The technical work of the observatory and the enthusiasm of its astronomers in spreading astronomical knowledge among the people has been solemnly and officially recognized by King ALFONSO XIII in awarding in 1914 the Gran Cruz de Alfonso XII to Fr. RICHARD CIRERA.

The scientific activities of the observatory are carried on by four departments — astronomy, terrestrial magnetism, atmo-



THE SOLAR DEPARTMENT, EBRO OBSERVATORY.

spheric electricity, and meteorology. A specialist is in charge of each department.

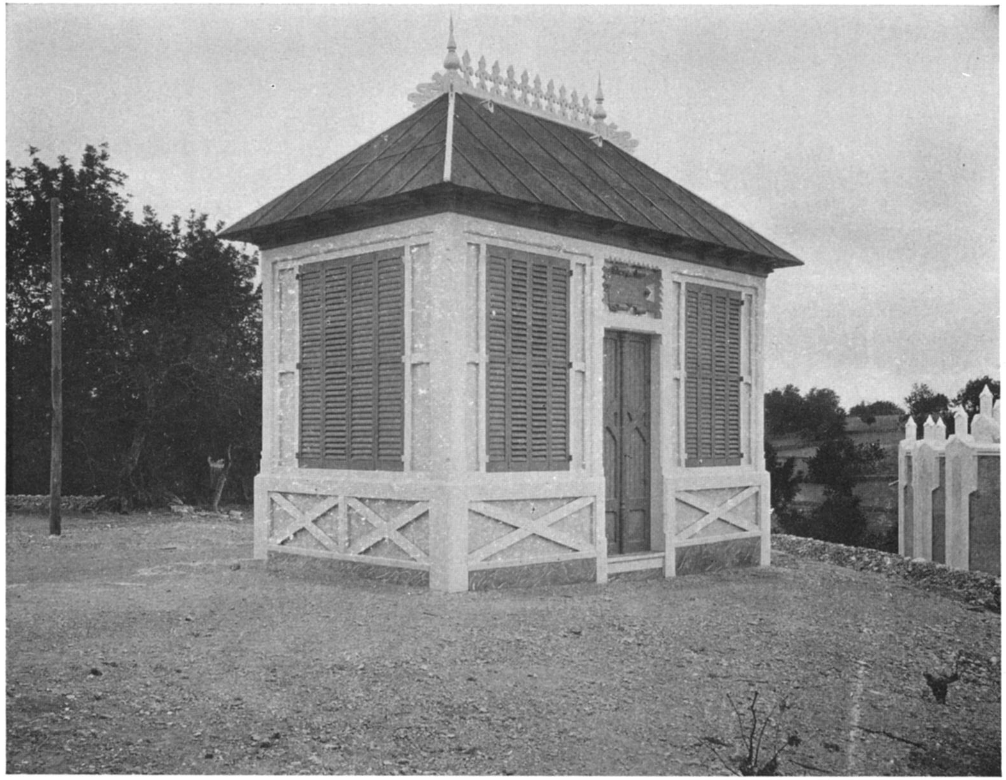
*Astronomical Department.* — Astronomical observations at Tortosa are confined solely to the Sun and the equipment is designed with this object in view. The equatorial, made by MAILLAT, of Paris, carries two objectives of 162 millimeters aperture and 2.10 meter focal length. One is corrected for the photographic rays and the other for the visual region. The right-ascension circle gives the second of time and the declination circle reads to 20″. The focal image of the Sun is about 20 millimeters in diameter. An enlarging system brings it to the standard size of 200 millimeters on the photographic plate. Photographs of the Sun are taken on every available day with the photographic equatorial. The heliographic positions of the sun-spots are deduced from the plate, either by the method used at Greenwich, by means of the position micrometer or by different graphs. The measured surface of the sun-spots is read in square millimeters and tenths of a square millimeter, and the reduced surface is computed to millionths of the solar hemisphere. Flocculi or calcium vapors in the Sun's cromosphere are studied by means of an Evershed spectroheliograph. An excellent spectrogoniometer of four prisms, in connection with a coelostat affords an opportunity of determining the radial velocities of different vapors of the solar atmosphere. The importance of solar radiation work to determine the solar constant was early recognized and fully realized by the director. Observations have been carried on daily with an Ångstrom compensating pyrheliometer.

*Magnetic Department.*—The magnetic observations consist in the determination of absolute values of the intensity and direction of the Earth's magnetic field and of the variation of its intensity. The absolute measures are taken in a pavilion very favorably located. There is not a single trolley line connecting the busy Tortosa with Roquetas and Arrabal del Jesús, and this is a great blessing the observatory people are to be thankful for. The industrial electric currents rendered worthless the magnetic observations of the magnetic observatory of Parc Saint Maur, near Paris. The magnetic observatories of Greenwich, Kiev, Perpignan, Nice, Lyons and Manila either

had to be transferred to a safer place or had to be abandoned or greatly modified. Again magnetic iron is highly detrimental to absolute magnetic measures. A careful geologic and petrographic study of the region surrounding the observatory was made before the site of the magnetic pavilion was chosen. Wood was the only material of construction: the locks, latches, hinges, keys, screws, every metallic piece is of copper; the supporting piers are of stone and marble. Since the distance between the absolute measures pavilion and the variation pavilion is only 14 meters, the magnetic field can be taken to be the same for both observing houses. Wood, local stone, copper and zinc were used for construction; every material was tested by the Dover magnetometer before it was admitted and used. The thermographs show practically no variation of temperature in the inclosed piers.

It will be well to recall to our minds that the seven magnetic elements are: the declination, the inclination, the horizontal component, the vertical component, the total intensity, the north geographic component and the east component. Out of these seven elements, the three which are most easily determined by absolute measures are the declination, the horizontal component and the inclination. The Ebro Observatory is provided with a Dover unifilar magnetometer, Kiew type, whose constants were determined at the National Physical Laboratory of England, to measure the declination and the horizontal component. A Schulze terrestrial inductor, Potsdam type, measures the inclination, to a tenth of a minute of arc. In the variation pavilion the declination is measured by a declinometer, the horizontal component by a bifilar and the vertical component by a magnetic balance, all of Mascart type.

The excellent location of the observatory and the efficiency of its apparatus caused the Spanish Government to request the director that the Ebro Observatory be made a central magnetic station in the construction of the magnetic chart of Spain. It is intended to combine the magnetic observations of Tortosa with those already made at San Fernando and Lisbon. It is expected that the comparison of the magnetic observations of Val Joyeux, near Paris, with those of Tortosa will eventually lead to the value of the secular variation corresponding to the south of France.



Pavilion for Absolute Magnetic Measures, Ebro Observatory.

*Electro-Meteorologic Department.*—It is needless to say that Fortin and Tonnelot barometers, maximum and minimum thermometers, Arago actinometer, sunshine recorder, Cornu photopolarimeter, Besson nephoscope, Richard barographs, thermographs, anemographs, and hydrographs are the apparatus used for the daily or weekly record of the atmospheric variations and for the local forecast of the weather.

In the electric section, the ions, the atmospheric potential, Herzt waves and telluric currents are the object of investigation. The study of atmospheric ions can be accomplished by finding either relative values that give a vague idea of the ionization of the air or absolute values of the conductivity and of its elements. We know the relative values from the determination of the coefficient of electric dispersion by means of an Elster and Geitel apparatus. The number of ions and the absolute conductivity of the air is computed from the data obtained from a Gerdien apparatus of the early type. A registering apparatus in connection with a Thompson-Chauvenau collector and two Thompson-Mascart quadrant electrometers of different sensibility record the variations of atmospheric potential. Absolute measures of atmospheric potential are made at an isolated station, at some distance from the observatory, in order to be free from the effect of local perturbations produced by buildings and surrounding trees.

It is well known that when we have an electrical disturbance in the atmosphere, this disturbance is the source of electromagnetic waves similar to those produced in wireless telegraphy. These waves may be detected and recorded by a special apparatus similar to that used as a receiver for ordinary waves of wireless telegraphy. This instrument is known as a ceraunograph. The Tortosa ceraunograph gives a continuous record of electric storms occurring in the neighborhood or within a certain distance from the Ebro Valley.

Besides artificial electric waves excited by the trolley cars, motors and electric plants of our industrial cities, there are natural electric waves moving along the crust of the Earth. Sometimes they have cut off telegraphic communication; at other times, as in 1859, between Portland and Boston, the difference of potential of the telluric currents between the ter-

minals of the line has been such that telegraphic messages could be sent thru. For the observation of telluric currents, the Ebro Observatory runs a 1,420-meter line, west-east, to el Colegio Máximo and another, north-south, to a point 1,280 meters distant from the observatory; the angle between the two lines is 87° 21′ towards the east. The entrance wires are joined to two Despretz and D'Arsonval galvanometers and the deviations are recorded on the photographic registering apparatus. The seismological equipment consists of a Vicentini seismograph and two Grablowitz pendulums.

*Publications.*—Four Memoirs have been published by the observatory staff. In the first the observatory was introduced to the astronomical world, its instruments described, its program outlined, and the results of its observations of the solar eclipse, August 30, 1905, made public. In the second, Rev. MARIANO BALCELLS, S. J., gives a detailed description of the astronomical instruments of the solar department and outlines the problems of solar research. The author had come to America to work under the direction of the inventor of the spectroheliograph and was taking several courses in the Massachusetts Institute of Technology when his life was untimely cut off. E. MERVEILLE, S. J., and J. GARCÍA MOLLÁ, S. J., are credited with the description of the instruments and exposition of the problems of the magnetic and electric departments.

Since 1910, the observatory issues a regular monthly bulletin, printed in two languages, Spanish and French. It gives the numerical data of observation in heliophysics, meteorology and geophysics. For a comparison of the results obtained in these three departments of research, these data are plotted in diagrams on which days and fractions of a day are taken as abscissae and the values in the proper unit of the particular element under consideration as ordinates.

These charts exhibit then, on the same page, for each hour of the day, the number, position and area of sun-spots and flocculi; the hours of sunshine and of clouds, the atmospheric pressure, humidity, temperature, direction and velocity of the wind, atmospheric potential and telluric currents; the magnetic intensity and declination, and, finally, the occurrence and intensity of seismic phenomena.

*Iberica.*—What the *Scientific American* is for the American, *Cosmos* for the Frenchman, *Nature* for the Englishman, that is *Iberica* for the Spaniard. The necessity of a weekly scientific magazine, well illustrated and with up-to-date articles was long felt by Spanish-speaking people. That *Iberica* supplies this need is plainly shown by the fact that two months after its appearance the copies of *Iberica* were spread all over the provinces of Spain and the different South American republics. I have seen *Iberica* on the shelves of the great libraries of Boston, New York and San Francisco, as well as in the private libraries of distinguished scientific men of this country.

MT. HAMILTON, January 20, 1915.

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## PERIODIC VARIATION IN THE POSITION OF THE MIRE IN 1914.

By R. H. TUCKER.

The position of the Mire with reference to the true meridian has been derived from the meridian-circle observations of the past year. Evidence of change in its position was apparent in the current reductions for clock errors, made usually once a week, and at the close of the year the definite computations of the azimuth furnish material for the complete comparison of positions.

It is necessary to consider all the sources of possible systematic error, in order that these shall be eliminated from the results. Systematic errors in the right ascensions of the circumpolar stars, employed for the determination of the azimuth of the meridian circle, might be suspected of producing apparent periodic changes in the position of the Mire. A very complete discussion of the determinations of the Mire was published in the *Lick Observatory Bulletin,* No. 213, in the year 1912. That discussion was based, primarily, on the observations of *Polaris,* during the fundamental work of the years 1905 to 1908, and the results were accordingly unaffected by systematic errors of right ascension. The results of the meridian-circle observa-